COURSE: Fan Noise

PRESENTER: Mr. David Nelson, P.E. INCE Bd.Cert., Nelson Acoustics
Ms. Cathy Biber, Biber Thermal Design Ltd.

TARGET AUDIENCE: This is a seminar about the proper selection, implementation and understanding of fan mechanics and fan noise. It is not about designing fans, per se. So the target audience is anyone who participates in the design of systems that use fans. The target audience includes GRC and contractor engineers, project managers and task monitors involved in fan noise research, development of flight hardware, and laboratory industrial facilities.

COURSE MATERIALS: Each attendee will receive a binder reproducing information presented during the course.

Fan Noise

Mr. David Nelson, P.E. INCE Bd.Cert.,Nelson Acoustics
Ms. Cathy Biber, Biber Thermal Design Ltd.

This course will provide an introduction to acoustics, relevant noise criteria, factors affecting noise produced by fans, and principles of fan noise estimation. It will also include demonstrations of laboratory equipment and processes for fan noise/performance characterization as well as discussion of case studies in fan noise control and consideration of fan noise problems presented by attendees. This is a seminar about the proper selection, implementation and understanding of fan mechanics and fan noise. It is not about designing fans, per se. The target audience is anyone who participates in the design of systems that use fans. The engineering information needed to do this job correctly is currently sparse, but the technology is presently coming on line to permit confident a priori engineering assessment of fan performance and noise.

The first two days will consist of classroom lecture (see agenda below). The morning of the third day will feature a visit to GRC's Acoustical Testing Laboratory to witness experimental characterization of fan noise and performance using a fan test plenum apparatus. On the afternoon of the third day, case studies will be presented, and the instructor and guest lecturers will address specific fan design and fan noise control issues and questions that attendees have brought to the course.

DRAFT AGENDA

Day 1 AM

Fundamentals of Acoustics

Motivation: Why should NASA care about fan noise?

Straightening Out Concepts and Terminology:

- Frequency, Spectrum, and Pitch
- Filters: A-weighted, octave bands, one-third octave bands
- Amplitude and Level, “dBs”
- Sound Pressure, Sound Power, Sound Intensity
- dB Math
- Sound Propagation

Criteria:

- International Space Station requirements
- Speech Interference
- Product, architectural and industrial criteria
- Sound Quality

Day 1 PM, Day 2 AM

Fans:

- Is there such a thing as an intrinsically quiet fan? Noise control at the source
- Types of fans: choosing the right one for the job.
- Curves: knowing what the fan is actually going to do when loaded. Fan curves, system curves, efficiency curves, noise curves and contours, including examples from recent tests
- Testing fans: flow/acoustic testing per ISO 10302
- Fans in parallel or series: what to expect, and not expect.
- Reduce system resistance. Achieve reduced power consumption or noise, your choice.
- Fan scaling laws: a parametric study of fan noise in a fan-cooled system. Moore’s Law and dBA/year.
- Non-dimensional curves: comparing fans against one another and against the task at hand
- Fan selection: optimize type, diameter and speed for maximum efficiency, minimum noise
- “Hobbling” of fan curves: effect of non-ideal inflow and outflow conditions on flow and noise emission. What will the fan do when installed?
- Case study: a fan selection debacle
- Empirical noise estimation methods: Graham/ASHRAE, Maling, etc.
- Fan design factors affecting noise emission: features to look for.
- Review

Day 2 AM, Day 2 PM
Interfacing Thermal Cooling and Noise Control Design:
Cathy Biber, Biber Thermal Design, Ltd.

- Thermo-acoustic tradeoffs
- First-order analysis for both acoustic and thermal design,
- Experimental techniques for measuring acoustic and thermal performance during the product development process.
- Development timelines,
- General goals of meeting specifications, and
- Setting appropriate requirements.

Day 3 AM
GRC's ATL: Supporting Low-Noise Design for Space Flight Hardware
Beth Cooper, Manager, NASA GRC Acoustical Testing Laboratory

Visit to Acoustical Testing Laboratory:
Witness simultaneous flow/acoustic testing of a fan.

Day 3 AM-PM
Case Studies provided by NASA and external attendees.

About the instructors

David A. Nelson, P.E., INCE Bd. Cert., is an acoustical consultant with more than 20 years of experience in product design for sound quality, acoustical measurement and analysis, and acoustics and noise control instruction. His experience also includes noise and vibration control for buildings and manufacturing processes, acoustical test facility design, and directing a nationally recognized, NVLAP-accredited acoustics laboratory. He also has extensive practical experience in industrial and machinery noise control.

Mr. Nelson is familiar with GRC facilities, research, operations, and personnel, having provided training, consulting, and product development services for the past 10 years. Mr. Nelson has extensive experience in low-noise design and sound quality work for the commercial products industry and is an expert on gas flow systems noise (including fan noise related to cooling systems) for computer and information technology equipment and large industrial applications.

Cathy Biber, Ph.D., Principal of Biber Thermal Design, has nearly two decades of experience implementing thermal solutions and is the holder of several patents. Her background includes work in process equipment, electronics cooling, heat sinks and projectors, and a PhD from MIT. Recent projects include:

- Determine diode current limits for reduced water flow to equipment in pulsed operation
- Recommend alternate RF transmitter die attach materials
- Construct RC network model of cooling system
- Evaluate thermal effects of vacuum pump enclosures
- Size heating and cooling capacities for closed, outdoor precision equipment
- Quantify effect of thermocouple positional variations on "measured" data